



(11) **EP 1 668 045 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
03.10.2012 Bulletin 2012/40

(51) Int Cl.:
C08F 10/06 ^(2006.01) **C08F 4/654** ^(2006.01)

(21) Application number: **04781510.5**

(86) International application number:
PCT/US2004/026836

(22) Date of filing: **18.08.2004**

(87) International publication number:
WO 2005/035596 (21.04.2005 Gazette 2005/16)

(54) **CATALYST COMPOSITION WITH MONOCARBOXYLIC ACID ESTER INTERNAL DONOR AND PROPYLENE POLYMERIZATION PROCESS**

KATALYSATORZUSAMMENSETZUNG MIT MONOCARBONSÄUREESTER ALS INTERNEM
DONATOR UND PROPYLENPOLYMERISATIONSVERFAHREN

COMPOSITION DE CATALYSEUR A DONNEUR INTERNE D'ESTER D'ACIDE
MONOCARBOXYLIQUE ET PROCEDE DE POLYMERISATION DE PROPYLENE

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PL PT RO SE SI SK TR**

(30) Priority: **23.09.2003 US 505312 P**

(43) Date of publication of application:
14.06.2006 Bulletin 2006/24

(73) Proprietor: **Dow Global Technologies LLC**
Midland, MI 48674 (US)

(72) Inventors:
• **BRADLEY, Jeffery, S.**
Midland, MI 48640 (US)
• **CHEN, Linfeng**
Sugar Land, TX 77478 (US)
• **SHEARD, William, George**
Houston, TX 77041 (US)

• **ZUM MALLEEN, Michael, Philip**
Sugar Land, TX 77479 (US)

(74) Representative: **Hull, John Philip et al**
Beck Greener
Fulwood House
12 Fulwood Place
London WC1V 6HR (GB)

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to stereoselective Ziegler-Natta catalyst compositions for use in the polymerization of propylene having improved control over polymerization activity and reactor process continuity through the use of carefully chosen mixtures of selectivity control agents. Ziegler-Natta propylene polymerization catalyst compositions are well known in the art. Typically, these compositions include a transition metal compound, especially a mixed titanium, magnesium and halide containing compound in combination with an internal electron donor (referred to as a procatalyst); a co-catalyst, usually an organoaluminum compound; and a selectivity control agent (SCA). Examples of such Ziegler-Natta catalyst compositions are shown in: US-A-4,107,413; US-A-4,115,319; US-A-4,220,554; US-A-4,294,721; US-A-4,330,649; US-A-4,439,540; US-A-4,442,276; US-A-4,460,701; US-A-4,472,521; US-A-4,540,679; US-A-4,547,476; US-A-4,548,915; US-A-4,562,173; US-A-4,728,705; US-A-4,816,433; US-A-4,829,037; US-A-4,927,797; US-A-4,990,479; US-A-5,028,671; US-A-5,034,361; US-A-5,066,737; US-A-5,066,738; US-A-5,077,357; US-A-5,082,907; US-A-5,106,806; US-A-5,146,028; US-A-5,151,399; US-A-5,153,158; US-A-5,229,342; US-A-5,247,031; US-A-5,247,032 and US-A-5,432,244.

[0002] Catalyst compositions designed primarily for the polymerization of propylene or mixtures of propylene and ethylene generally include a selectivity control agent in order to affect polymer properties, especially tacticity or stereoregularity of the polymer backbone. As one indication of the level of tacticity, especially the isotacticity of polypropylene, the quantity of such polymer that is soluble in xylene or similar liquid that is a non-solvent for the tactic polymer is often used. The quantity of polymer that is soluble in xylene is referred to as xylene solubles content or XS. In addition to tacticity control, molecular weight distribution (MWD), melt flow (MF), and other properties of the resulting polymer are affected by use of a SCA as well. It has also been observed that the activity of the catalyst composition as a function of temperature may be affected by the choice of SCA. Often however, a SCA which gives desirable control over one polymer property, is ineffective or detrimental with respect to additional properties or features. Conversely, an SCA that is effective in combination with one procatalyst may not be effective when used in combination with a different procatalyst.

[0003] It is known that the use of certain alkoxy derivatives of aromatic carboxylic acid esters, especially ethyl p-ethoxybenzoate (PEEB), in combination with a Ziegler-Natta procatalyst composition containing a monoester of an aromatic monocarboxylic acid, exemplified by ethyl benzoate, results in an inferior catalyst composition possessing lower overall polymerization activity and polymers having relatively low isotacticities and increased oligomer contents, all of which are generally undesired results.

[0004] Disadvantageously however, alkoxysilane SCA's, exemplified by dicyclopentylmethoxysilane (DCPDMS), methylcyclohexylmethoxysilane (MChDMS) and n-propyltrimethoxysilane (NPTMS) when used in combination with ethylbenzoate internal electron donor results in catalyst compositions that are not generally self-extinguishing. That is, these compositions can give polymerization process control problems, especially sheeting and formation of large polymer chunks due to hard to control temperature excursions allowing polymer particles to form agglomerates. Such catalyst compositions are not "self-extinguishing". Rather, at higher reaction temperatures, they tend to be more active, resulting in difficult to control processes. In addition, under conditions of a reactor upset or a power outage, the normally fluidized reaction bed of a gas phase polymerization reactor may settle to the diffuser plate of the reactor. In that state, continued polymerization may generate excessive temperatures, resulting in fusion of the entire reactor contents into a solid mass which requires opening of the reactor and laborious effort to remove the polymer mass.

[0005] Use of mixtures of SCA's in order to adjust polymer properties is known. Examples of prior art disclosures of catalyst compositions making use of mixed SCA's, especially mixtures of silane or alkoxysilane SCA's include: US-A-5,100,981, US-A-5,192,732, US-A-5,414,063, US-A-5,432,244, US-A-5,652,303, US-A-5,844,046, US-A-5,849,654, US-A-5,869,418, US-A-6,066,702, US-A-6,087,459, US-A-6,096,844, US-A-6,111,039, US-A-6,127,303, US-A-6,133,385, US-A-6,147,024, US-A-6,184,328, US-A-6,303,698, US-A-6,337,377, WO 95/21203, WO 99/20663, and WO 99/58585. References generally showing mixtures of silanes with monocarboxylic acid ester internal electron donors or other SCA's include: US-A-5,432,244, US-A-5,414,063, JP61/203,105, and EP-A-490,451.

[0006] US-A-5,414,063 discloses temporarily slowing or killing the production of polypropylene using a fourth generation catalyst system containing a solid magnesium chloride supported titanium tetrachloride catalyst component containing an internal strong electron donor in combination with a silicon compound, and an organoaluminum compound (cocatalyst), by the introduction, while idling the reactor, of an amount of an external strong electron donor to an ongoing propylene polymerization reaction. The preferred external strong electron donor is PEEB and in an exemplified process it is used to kill the production of polypropylene using a fourth generation catalyst system comprising diethyl phthalate as the internal strong electron donor and MChDMS as an internal weak electron donor. It is specifically stated, at column 7, lines 51/54, that the external strong electron donor is not part of the catalyst system but plays an important role in shutting down the reaction mechanism.

[0007] US-A-5,432,244 (corresponding to EP-A-0490451) discloses the polymerization of propylene or a mixture

comprising propylene and one or more alpha-olefins and, optionally, one or more diolefins by contacting the propylene or the mixture of olefins in at least one reaction zone, under polymerization conditions, with a catalyst system comprising (i) a solid catalyst precursor, which includes magnesium; titanium; a halogen which is chlorine, bromine, or iodine, or mixtures thereof; and a mono- or polycarboxylic acid ester; (ii) a hydrocarbylaluminum cocatalyst; and (iii) a mixture of SCAs comprising a mono- or polycarboxylic acid ester and a silicon compound containing at least one silicon-oxygen-carbon linkage with the proviso that (a) the atomic ratio of aluminum to titanium is in the range of about 5 to about 300; and (b) the molar ratio of the ester to silicon compound in the mixture of SCAs is at least about 1.5:1. Specified examples of suitable mono- or polycarboxylic acid ester SCAs include *inter alia* some specific monoesters of aromatic carboxylic acids and specified examples of silicon SCA include *inter alia* methylcyclohexyldimethoxysilane & cyclohexyltrimethoxysilane but exemplified mixtures are limited to mixtures of PEEB with diisobutyldimethoxysilane, n-propyltrimethoxysilane, ethyltriethoxysilane or tetraethoxysilane.

[0008] Despite the advances occasioned by the foregoing disclosures, there remains a need in the art to provide an aromatic monocarboxylic acid ester internal electron donor containing Ziegler-Natta catalyst composition for the polymerization of olefins, especially propylene and propylene containing mixtures, wherein the catalyst composition retains the advantages of alkoxysilane SCA containing catalyst compositions with regard to polymer properties, but additionally possesses improved temperature/activity properties. Especially desired are such compositions that are inherently self-extinguishing with regard to catalyst activity as a function of temperature, thereby leading to reduced polymer agglomerate formation, improved polymerization process control, and increased immunity to reactor upset or power outages.

SUMMARY OF THE INVENTION

[0009] The present invention provides a catalyst composition for the polymerization of propylene or mixtures of propylene and one or more copolymerizable comonomers, said catalyst composition comprising one or more Ziegler-Natta procatalyst compositions comprising one or more transition metal compounds and one or more monoesters of aromatic carboxylic acid internal electron donors; one or more aluminum containing cocatalysts; and a premixture of two or more different selectivity control agents, said SCA premixture comprising (i) from 70 to 98 mol percent of ethyl p-ethoxybenzoate and (ii) from 30 to 2 mol percent of dicyclopentyldimethoxysilane.

[0010] The present invention also provides a method of polymerizing propylene or mixtures of propylene and one or more copolymerizable comonomers under polymerization conditions using the previously described Ziegler-Natta catalyst composition comprising said mixture of SCA's. More particularly, the process comprises contacting propylene or a mixture of propylene and one or more copolymerizable comonomers under polymerization conditions at a temperature from 45 to 95 °C, preferably from 67 to 90 °C, and most preferably from 68 to 85 °C with a self-extinguishing catalyst composition comprising one or more Ziegler-Natta procatalyst compositions comprising one or more transition metal compounds and one or more internal electron donors selected from the group consisting of esters of aromatic monocarboxylic acids; one or more aluminum containing cocatalysts; and a premixture of two or more different selectivity control agents, said SCA premixture comprising (i) from 70 to 98 mol percent of ethyl p-ethoxybenzoate and (ii) from 30 to 2 mol percent of dicyclopentyldimethoxysilane; and mixing, prior to the contacting, (i) the ethyl p-ethoxybenzoate and (ii) the dicyclopentyldimethoxysilane to form the SCA premixture.

[0011] Highly desirably, the polymerization is conducted under conditions of temperature and SCA content such that no substantial polymer agglomerates are formed in the polymer product and sheeting or fouling of the reactor surfaces is reduced, and preferably, eliminated. The catalyst containing ethyl benzoate as internal electron donor typically reach the optimal productivity at 65 - 67 °C with PEEB as SCA, while the optimal temperature for using PEEB-alkoxysilane mixture is around 85 °C. Because a mixture of SCA compounds is employed, the reaction temperature can be safely raised compared to processes employing only a single SCA, without sacrificing control over reaction conditions or reducing productivity. The present process conditions result in greater catalyst activity.

[0012] Additionally, the use of higher reaction temperatures results in greater hydrogen response thereby reducing the amount of hydrogen required to achieve a given polymer molecular weight and reducing the risk of fire or explosion or allowing the production of products that otherwise cannot be produced. Finally, increasing the polymerization temperature results in improved production efficiencies since cooling requirements are reduced.

[0013] Although a broad range of compounds are known generally as selectivity control agents, a particular catalyst composition may have a specific compound or group of compounds with which it is especially compatible. The present invention provides a catalyst composition for the polymerization of propylene or mixtures of propylene and one or more copolymerizable comonomers which is especially useful with Ziegler-Natta procatalyst compositions formed by halogenation of mixed alkoxide metal compounds. As a result of the present inventors discovery, it has been unexpectedly discovered that in the foregoing operating range of mixed SCA's the advantages of using an alkoxysilane in combination with an aromatic monocarboxylic acid ester internal electron donor can be largely retained while simultaneously improving the self-extinguishing properties of the polymerization catalyst. Additional benefits of the invention include preparation of polymers having narrowed molecular weight distribution and greater tacticity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Figures 1 and 2 are plots of selected properties of the polymers of Example 2.

DETAILED DESCRIPTION

[0015] All reference to the Periodic Table of the Elements herein shall refer to the Periodic Table of the Elements, published and copyrighted by CRC Press, Inc., 2001. Also, any reference to a Group or Groups shall be to the Group or Groups as reflected in this Periodic Table of the Elements using the IUPAC system for numbering groups. The term "aromatic" or "aryl" refers to a polyatomic, cyclic, ring system containing $(4\delta+2)$ π -electrons, wherein δ is an integer greater than or equal to 1.

[0016] The term "comprising" and derivatives thereof is not intended to exclude the presence of any additional component, step or procedure, whether or not the same is disclosed herein. In order to avoid any doubt, all compositions claimed herein through use of the term "comprising" may include any additional additive, adjuvant, or compound, unless stated to the contrary. In contrast, the term, "consisting essentially of" if appearing herein, excludes from the scope of any succeeding recitation any other component, step or procedure, excepting those that are not essential to operability. The term "consisting of", if used, excludes any component, step or procedure not specifically delineated or listed. The term "or", unless stated otherwise, refers to the listed members individually as well as in any combination. The term "inert" means the substance or substituent is substantially non-interfering with any desired reaction or result disclosed herein.

[0017] Unless stated to the contrary or conventional in the art, all parts and percents used herein are based on weight. The term "(poly)alkyl- substituted" means optionally more than one alkyl substituent. The term "mixture" when used with respect to SCA's, means the use of two or more SCA components, simultaneously during at least a portion of a polymerization. The individual SCA's may be added separately to a reactor or premixed and added to the reactor in the form of the desired mixture. In addition, other components of the polymerization mixture, including the procatalyst, may be combined with one or more of the SCA's of the mixture, and/or the procatalyst, cocatalyst and a portion of the monomer optionally prepolymerized, prior to addition to the reactor.

[0018] The benefits of the invention are obtained by operation in a range of limited availability of alkoxysilane compound, such that good process economies, especially catalyst productivity at reaction temperatures and desirable polymer properties exemplified by melt flow, molecular weight distribution, and/or xylene solubles content, especially MF, are largely retained, while substantially reducing the polymerization activity of the catalyst composition at elevated reactor temperatures, especially reactor temperatures above 90°C. Temperatures reported herein are average temperatures of the reaction mixture. Isolated regions of the reactor may experience localized temperatures that differ from the previously stated limits.

[0019] Catalyst compositions demonstrating decreased activity at elevated temperatures, especially at temperatures greater than 100 °C, more preferably greater than 80 °C compared to a standard temperature such as 67 °C are said to be self-extinguishing. In addition, as a practical standard, if a polymerization process, especially a fluidized bed, gas-phase polymerization, running at normal processing conditions is capable of interruption and resulting collapse of the bed without adverse consequences with respect to agglomeration of polymer particles, the catalyst composition is said to be self-extinguishing.

[0020] A complex calculation may be used to compare catalyst activities when polymers having different tacticities (measured as xylene solubles or XS) are prepared. The empirically derived equation used to convert catalyst activity to that of a standard polymer containing 4 percent XS is:

$$Y_4 = Y + 31.52 - 10.31X + 0.61X^2,$$

wherein

Y_4 is normalized activity (kg/g procatalyst) at 4.0 percent XS,

Y is the measured catalyst activity (kg/g procatalyst), and

X is the XS content of the polymer in percent measured by the ^1H NMR technique of USP 5,539,309, or the gravimetric XS method of 21 CFR 177.1520.

[0021] It is to be understood that the present invention is not limited to the use of any particular polymerization conditions in practice. In fact, the invention is particularly beneficial when employed under gas phase polymerization conditions, in as much as control of reaction temperature and prevention of polymer agglomeration is especially critical in a gas phase polymerization, particular under conditions of a reactor upset or power outage.

[0022] Examples of alkoxysilanes for use in the mixture of SCA's herein are selected from dicyclopentyl dimethoxysi-

lane, methylcyclohexyldimethoxysilane, ethylcyclohexyldimethoxysilane, dicyclohexyldimethoxysilane, methylcyclopentyldimethoxysilane, cyclopentyltrimethoxysilane, isopropylcyclohexyldimethoxysilane, ethylcyclopentyldimethoxysilane, cyclopentylpyrrolidinodimethoxysilane, bis(pyrrolidino)dimethoxysilane, bis(perhydroisoquinolino)dimethoxysilane, bis(perhydroquinolino)dimethoxysilane, bis(perhydroisoindolino)dimethoxysilane, bis(perhydroindolino)dimethoxysilane, and (perhydroquinolino)(perhydroisoquinolino)dimethoxysilane. Most highly preferred alkoxysilane is dicyclopentyldimethoxysilane and methylcyclohexyldimethoxysilane.

[0023] Suitable esters of aromatic monocarboxylic acids or derivatives thereof for use in combination with the foregoing alkoxysilane compounds in the SCA mixture include C_{1-10} alkyl or cycloalkyl esters of aromatic monocarboxylic acids. Suitable substituted derivatives thereof include compounds substituted both on the aromatic ring(s) or the ester group with one or more substituents containing one or more Group 14, 15 or 16 heteroatoms, especially oxygen. Examples of such substituents include (poly)alkylether, cycloalkylether, aryether, aralkylether, alkylthioether, arylthioether, dialkylamine, diarylamine, diaralkylamine, and trialkylsilane groups. Preferred are C_{1-20} hydrocarbyl esters of benzoic acid wherein the hydrocarbyl group is unsubstituted or substituted with one or more Group 14, 15 or 16 heteroatom containing substituents and C_{1-20} (poly)hydrocarbyl ether derivatives thereof, more preferred are C_{1-4} alkyl benzoates and C_{1-4} ring alkylated derivatives thereof, especially, methyl benzoate, ethyl benzoate, propyl benzoate, methyl p-methoxybenzoate, methyl p-ethoxybenzoate, ethyl p-methoxybenzoate, and ethyl p-ethoxybenzoate, and most especially, ethyl benzoate and ethyl p-ethoxybenzoate.

[0024] An especially preferred combination of SCA components is a mixture of ethyl p-ethoxybenzoate and dicyclopentyldimethoxysilane or methylcyclohexyldimethoxysilane.

[0025] Preferred SCA mixtures according to the invention are those comprising from 70 to 98 mol percent, more preferably from 75 to 95 mol percent, most preferably from 80 to 90 mol percent of one or more esters of one or more aromatic monocarboxylic acids or substituted derivatives thereof, and from 30 to 2 mol percent, more preferably from 25 to 5 mol percent, and most preferably from 20 to 10 mol percent of one or more of the specified alkoxysilane compounds.

[0026] If larger quantities of monoester are employed in the SCA mixture, the polymerization activity and selectivity of the reaction are adversely affected. If larger quantities of alkoxysilane are employed, the self-extinguishing benefits of the invention are not obtained and increased reaction temperatures, especially temperatures from 67-90°C, preferably from 68-85 cannot be employed.

[0027] The total molar quantity of the SCA mixture employed in the present invention based on moles of transition metal is desirably from 0.1 to 1000, more desirably from 0.5 to 500 and most preferably from 1 to 100. The total molar quantity of cocatalyst employed in the present invention based on total moles of SCA mixture is desirably from 0.1 to 1000, more desirably from 1 to 50 and most preferably from 2 to 30.

[0028] Ziegler-Natta procatalysts for use in the present invention comprise a solid complex derived from a transition metal compound, for example, titanium-, zirconium-, chromium- or vanadium-hydrocarbyloxides, hydrocarbyls, halides, or mixtures thereof; and a Group 2 metal compound, especially a magnesium halide. Preferred precursors of the procatalysts comprise a mixture of titanium halides supported on magnesium halide compounds.

[0029] Any of the conventional Ziegler-Natta, transition metal compound containing procatalysts can be used in the present invention. The procatalyst component of a conventional Ziegler-Natta catalyst preferably contains a transition metal compound of the general formula TrX_x where Tr is the transition metal, X is a halogen or a C_{1-10} hydrocarboxyl or hydrocarbyl group, and x is the number of such X groups in the compound in combination with the foregoing Group 2 metal compound. Preferably, Tr is a Group 4, 5 or 6 metal, more preferably a Group 4 metal, and most preferably titanium. Preferably, X is chloride, bromide, C_{1-4} alkoxide or phenoxide, or a mixture thereof, more preferably chloride.

[0030] Illustrative examples of suitable transition metal compounds that may be used to form a Ziegler-Natta procatalyst are $TiCl_4$, $ZrCl_4$, $TiBr_4$, $Ti(OC_2H_5)_3Cl$, $Zr(OC_2H_5)_3Cl$, $Ti(OC_2H_5)_3Br$, $Ti(OC_3H_7)_2Cl_2$, $Ti(OC_6H_5)_2Cl_2$, $Zr(OC_2H_5)_2Cl_2$, and $Ti(OC_2H_5)Cl_3$. Mixtures of such transition metal compounds may be used as well. No restriction on the number of transition metal compounds is made as long as at least one transition metal compound is present. A preferred transition metal compound is a titanium compound.

[0031] Examples of suitable Group 2 metal compounds include magnesium halides, dialkoxymagnesiums, alkoxy-magnesium halides, magnesium oxyhalides, dialkylmagnesiums, magnesium oxide, magnesium hydroxide, and carboxylates of magnesium. A most preferred Group 2 metal compound is magnesium dichloride.

[0032] Highly desirably, the procatalysts employed in the invention are derived from magnesium compounds. Examples include anhydrous magnesium chloride, magnesium chloride adducts, magnesium dialkoxides or aryloxides, or carboxylated magnesium dialkoxides or aryloxides. Preferred compounds are magnesium di(C_{1-4})alkoxides, especially diethoxymagnesium. Additionally the procatalysts desirably comprise titanium moieties. Suitable sources of titanium moieties include titanium alkoxides, titanium aryloxides, and/or titanium halides. Preferred compounds used to prepare the procatalysts comprise one or more magnesium- di(C_{1-4})alkoxides, magnesium dihalides, magnesiumalkoxyhalides, or mixtures thereof and one or more titanium tetra(C_{1-4}) alkoxides, titanium tetrahalides, titanium(C_{1-4})alkoxyhalides, or mixtures thereof.

[0033] Various methods of making precursor compounds used to prepare the present procatalysts are known in the

art. These methods are described in US-A-5,034,361; 5,082,907; 5,151,399; 5,229,342; 5,106,806; 5,146,028; 5,066,737; 5,077,357; 4,442,276; 4,540,679; 4,547,476; 4,460,701; 4,816,433; 4,829,037; 4,927,797; 4,990,479; 5,066,738; 5,028,671; 5,153,158; 5,247,031; 5,247,032, and elsewhere. In a preferred method, the preparation involves chlorination of the foregoing mixed magnesium compounds, titanium compounds, or mixtures thereof, and may involve the use of one or more compounds, referred to as "clipping agents", that aid in forming or solubilizing specific compositions via a solid/solid metathesis. Examples of suitable clipping agents include trialkylborates, especially triethylborate, phenolic compounds, especially cresol, and silanes.

[0034] A preferred precursor for use herein is a mixed magnesium/titanium compound of the formula $Mg_dTi(OR^e)_eX_f$ wherein R^e is an aliphatic or aromatic hydrocarbon radical having 1 to 14 carbon atoms or COR' wherein R' is an aliphatic or aromatic hydrocarbon radical having 1 to 14 carbon atoms; each OR^e group is the same or different; X is independently chlorine, bromine or iodine; d is 0.5 to 5, preferably 2-4, most preferably 3; e is 2-12, preferably 6-10, most preferably 8; and f is 1-10, preferably 1-3, most preferably 2. The precursors are ideally prepared by controlled precipitation through removal of an alcohol from the reaction mixture used in their preparation. An especially desirable reaction medium comprises a mixture of an aromatic liquid, especially a chlorinated aromatic compound, most especially chlorobenzene, with an alkanol, especially ethanol, and an inorganic chlorinating agent. Suitable inorganic chlorinating agents include chlorine derivatives of silicon, aluminum and titanium, especially titanium tetrachloride or titanium trichloride, most especially titanium tetrachloride. Removal of the alkanol from the solution used in the chlorination, results in precipitation of the solid precursor, having especially desirable morphology and surface area. Moreover, the resulting precursors are particularly uniform particle sized and resistant to particle crumbling as well as degradation of the resulting procatalyst.

[0035] The precursor is next converted to a solid procatalyst by further reaction (halogenation) with an inorganic halide compound, preferably a titanium halide compound, and incorporation of an internal electron donor. If not already incorporated into the precursor in sufficient quantity, the electron donor may be added separately before, during or after halogenation. This procedure may be repeated one or more times, optionally in the presence of additional additives or adjuvants, and the final solid product washed with an aliphatic solvent. Any method of making, recovering and storing the solid procatalyst is suitable for use in the present invention.

[0036] One suitable method for halogenation of the precursor is by reacting the precursor at an elevated temperature with a tetravalent titanium halide, optionally in the presence of a hydrocarbon or halohydrocarbon diluent. The preferred tetravalent titanium halide is titanium tetrachloride. The optional hydrocarbon or halohydrocarbon solvent employed in the production of olefin polymerization procatalyst preferably contains up to 12 carbon atoms inclusive, more preferably up to 9 carbon atoms inclusive. Exemplary hydrocarbons include pentane, octane, benzene, toluene, xylene, alkylbenzenes, and decahydronaphthalene. Exemplary aliphatic halohydrocarbons include methylene chloride, methylene bromide, chloroform, carbon tetrachloride, 1,2-dibromoethane, 1,1,2-trichloroethane, trichlorocyclohexane, dichlorofluoromethane and tetrachlorooctane. Exemplary aromatic halohydrocarbons include chlorobenzene, bromobenzene, dichlorobenzenes and chlorotoluenes. Of the aliphatic halohydrocarbons, compounds containing at least two chloride substituents are preferred, with carbon tetrachloride and 1,1,2-trichloroethane being most preferred. Of the aromatic halohydrocarbons, chlorobenzene and o-chlorotoluene are particularly preferred.

[0037] Suitable Ziegler-Natta procatalysts that may be used in the present invention may be prepared substantially according to the teachings of US-A-4, 927,797; US-A-4,816,433 and US-A-4,839,321. Desirably, the procatalyst is obtained by (i) suspending a dialkoxy magnesium optionally mixed with a titanium tetraalkoxide in an aromatic hydrocarbon or halohydrocarbon that is liquid at normal temperatures, (ii) contacting the suspension with a titanium halide and further (iii) contacting the resulting composition a second time with the titanium halide, and contacting the mixture with an internal electron donor sometime during the treatment with the titanium halide in (ii). Internal electron donors for use in the present catalyst composition to provide tacticity control and catalyst crystallite sizing are aromatic monocarboxylic acid esters or (poly)alkyl ether derivatives thereof, especially C_{1-4} alkyl esters of benzoic acid, especially ethyl benzoate. The Ziegler-Natta, transition metal catalyst may also include an inert support material, if desired. The support should be an inert solid which does not adversely alter the catalytic performance of the transition metal compound. Examples include metal oxides, such as alumina, and metalloid oxides, such as silica.

[0038] Ziegler-Natta procatalyst compositions for use herein preferably are in the form of porous particles or crystallites of a relatively uniform size and shape, thereby allowing close face-to-face contacting between particles resulting in a relatively high bulk density in both a static or dynamic (fluidized) state. Although porous, the particles desirably have a gross morphology substantially in the shape of spheres, spheroid-oblates, grains, or polyhedrons, preferably polyhedrons having 10 or more sides. Desirably the ratio of longest axis to shortest axis of the particles is less than 1.2. The particles generally lack surface protrusions. Desirably, 90 percent of the particles are circumscribable by a sphere having a diameter equal in length to the major axis thereof. Such procatalyst particles are referred to as "morphology controlled" procatalysts. Because morphology controlled catalyst compositions produce polymer with high bulk density (suitably greater than or equal to 0.35 g/cm^3) and are capable of generating large quantities of heat per unit volume, they are conceptually prone to forming polymer particle agglomerates. The present invention desirably imparts self-extinguishing properties to the catalyst composition, and accordingly is especially well suited for use with morphology controlled catalyst

compositions.

[0039] Cocatalysts for use with the foregoing Ziegler-Natta catalysts according to the invention include organoaluminum compounds, such as trialkylaluminum-, dialkylaluminum hydride-, alkylaluminum dihydride-, dialkylaluminum halide-, alkylaluminumdihalide-, dialkylaluminum alkoxide-, and alkylaluminum dialkoxide- compounds containing from 1-10, preferably 1-6 carbon atoms in each alkyl- or alkoxide- group. Preferred cocatalysts are C₁₋₄ trialkylaluminum compounds, especially triethylaluminum (TEA) and dialkylaluminum chloride compounds, especially triethylaluminum. The quantity of cocatalyst employed may vary within wide limits but generally is employed in an amount from 1 to 100 moles per mole of transition metal compound in the procatalyst.

[0040] One suitable method of practicing a polymerization process according to the present invention comprises performing the following steps in any order or in any combination, or subcombination of individual steps:

- a) providing a Ziegler-Natta catalyst composition to a polymerization reactor;
- b) providing an organoaluminum cocatalyst compound to the polymerization reactor;
- c) providing a mixture of SCA's meeting the foregoing requirements to the polymerization reactor;
- d) providing one or more polymerizable monomers including propylene to the reactor; and
- e) extracting polymer product from the reactor.

[0041] In another suitable method of operation, the procatalyst is treated with the one or more esters of one or more aromatic monocarboxylic acids or substituted derivatives thereof (first SCA component) in the presence or absence of the aluminum compound cocatalyst. The resulting composition may be stored and shipped prior to use or used directly in a polymerization reaction according to the invention by combining the same with one or more alkoxysilanes (second SCA component) and the cocatalyst if not already present, optionally in combination with additional quantities of one or more monocarboxylic acid ester(s). In this embodiment, trialkylaluminum compounds are preferred cocatalysts. When used, this results in the procatalyst additionally comprising one or more esters of one or more aromatic monocarboxylic acids or substituted derivatives thereof and optionally an aluminum alkyl compound and the catalyst composition is prepared by combining the same with one or more alkoxysilanes, optionally in combination with additional quantities of one or more monocarboxylic acid ester(s) and/or one or more cocatalysts.

[0042] In another suitable method of operation, the procatalyst may be treated with the alkoxysilane SCA component (second SCA component), optionally in the presence of an aluminum cocatalyst compound. The resulting composition may also be stored and shipped prior to use or used directly in a polymerization reaction according to the invention wherein only the alkyl ester SCA component (first SCA component) is separately added, optionally in combination with additional quantities of one or more alkoxysilane(s). In this embodiment as well, trialkylaluminum compounds are preferred cocatalysts.

[0043] Regardless of the method of operation, it has been discovered that it is desirable to combine the alkoxysilane with an organoaluminum compound, especially a trialkylaluminum compound prior to use in the present invention and conversely, it is detrimental to combine the alkyl ester SCA component with an organoaluminum compound prior to use in the present invention. In particular, the alkoxysilane and aluminum cocatalyst compound may be precontacted for a time period from one second to several hours, preferably from 1 to 30 minutes, before contacting with the procatalyst and/or first SCA component in order to achieve improved efficiency.

[0044] The catalyst composition of the invention may be used in most all commercially known polymerization processes, including those incorporating a pre-polymerization step, whereby a small amount of monomer is contacted with the catalyst after the catalyst has been contacted with the co-catalyst and the selectivity control agent mixture or individual components thereof. Then, the resulting preactivated catalyst stream is introduced into the polymerization reaction zone and contacted with the remainder of the monomer to be polymerized, and optionally one or more of the SCA components. When used, this results in the procatalyst additionally comprising one or more alkoxysilane compounds and an aluminum alkyl compound and the catalyst composition is prepared by combining the same with one or more esters of one or more aromatic monocarboxylic acids or substituted derivatives thereof, optionally in combination with additional quantities of one or more alkoxysilane compounds and/or one or more cocatalysts.

[0045] Preferred polymerization processes in which the present invention is particularly suited include gas phase, slurry, and bulk polymerization processes, operating in one or more than one reactor. Suitable gas phase polymerization processes include the use of condensing mode as well as super condensing mode wherein gaseous components including added inert low boiling compounds are injected into the reactor in liquid form for purposes of heat removal. When multiple reactors are employed it is desirable that they operate in series, that is the effluent from the first reactor is charged to the second reactor and additional monomer or different monomer added to continue polymerization. Additional catalyst or catalyst components (that is procatalyst or cocatalyst) may be added, as well as additional quantities of the SCA mixture, another SCA mixture, or individual SCA's comprising the present SCA mixture. Highly desirably, the mixture of SCA's is added to only the first reactor of the series. In another preferred embodiment, the polymerization process, or at least one step thereof, is a solution or slurry polymerization.

[0046] In one embodiment, the process of the invention is conducted in two reactors in which two olefins, most preferably, propylene and ethylene, are contacted to prepare a copolymer. In one such process, polypropylene is prepared in the first reactor and a copolymer of ethylene and propylene is prepared in the second reactor in the presence of the polypropylene prepared in the first reactor. Regardless of the polymerization technique employed, it is understood that the mixture of SCA's and the catalyst composition to be employed, or at least the procatalyst component thereof may be contacted in the absence of other polymerization components, especially monomer, prior to addition to the reactor. In a preferred embodiment, the polymerization process is a solution polymerization.

[0047] The invention is further illustrated by the following examples that should not be regarded as limiting of the present invention. Unless stated to the contrary or conventional in the art, all parts and percents are based on weight.

Example 1

[0048] A titanium containing Ziegler-Natta catalyst composition is employed to produce polypropylene homopolymers. The catalyst composition includes a controlled morphology procatalyst prepared by slurring a mixture of a magnesium diethoxide and titanium ethoxide/chloride containing precursor corresponding to the formula $Mg_3Ti(OC_2H_5)_8Cl_2$ (made substantially according to US-A-5,077,357) with ethyl benzoate (0.10 ml/gram precursor) in a 50/50 (vol/vol) mixture of $TiCl_4$ /monochlorobenzene (MCB, 15.9 ml/gram precursor). After the mixture is heated at 70°C for 30 minutes, it is filtered. The resulting moist mass is slurried in a 50/50 $TiCl_4$ /MCB mixture (15.9 ml/gram precursor) and benzoyl chloride (0.056 ml/gram precursor) at 99°C for 10 minutes and filtered. The last process was repeated once with 0.10 ml/gram precursor at 95 °C for 10 minutes. The resulting solid is rinsed with isopentane and then dried with flowing warm nitrogen.

[0049] Propylene polymerizations are carried out in a 3.6 L, jacketed, stirred stainless steel reactor. All solvents and the reactor interior are dried prior to use. The reactor conditions employed are: an initial charge of 3.0 standard liters H_2 , 2.7 liters of liquid propylene, 2.5 ml of a 5 percent solution of triethylaluminum (TEA) in heptane, measured quantities of SCAs for a total amount of 0.35 mmol (calculated to give a SCA/Ti ratio of 70/l and a Al/SCA molar ratio of 2.0), and 16.43 mg of the procatalyst as a 5.0 percent mineral oil slurry. Catalyst components are injected into the reactor at 60 °C. Polymerization is conducted at 67 °C for one hour. Upon completion of polymerization, the reactor is vented to ambient pressure and opened to the atmosphere.

[0050] The SCA mixtures tested include: dicyclopentylmethoxysilane (DCPDMS)/ PEEB, methylcyclohexyldimethoxysilane (MChDMS)/ PEEB, diisobutyldimethoxysilane (DiBDMS)/PEEB, and n-propyltrimethoxysilane (NPTMS)/ PEEB. Normalized activity (Y_4) for the various SCA combinations, amounts and temperatures is provided in Table 1.

Table 1. Polymerization Results

Run	SCA mixture	Silane/Ester (mol percent)	Activity, Y_4 (kg/g procat.)	Y_4 increase (percent)
1*	DCPDMS/PEEB	0/100	22.0	
2	"	5/95	29.0	32
3	"	20/80	28.2	28
4*	"	40/60	33.4	52
5*	MChDMS/PEEB	0/100	23.7	
6*	"	5/95	28.1	19
7*	"	20/80	29.4	24
8*	"	40/60	26.3	11
9*	DiBDMS/PEEB	0/100	25.8	
10*	"	5/95	27.2	5
11*	"	20/80	27.3	6
12*	"	40/60	30.2	17
13*	NPTMS/PEEB	0/100	23.7	
14*	"	5/95	28.1	19
15*	"	20/80	23.5	decrease
16*	"	40/60	21.1	decrease
* Comparative, not an example of the invention				

[0051] As may be seen by reference to the results of Table 1, by using certain mixtures of SCA's according to the

invention, improved polymerization activity (normalized to standard XS content) may be obtained compared to use of the carboxylic acid ester compound alone and compared to the use of an SCA mixture containing a silane that lacks a 5- or 6-membered cyclic group.

Example 2

[0052] A continuous, gas phase, fluidized bed polymerization is employed to polymerize propylene under selected reaction conditions employing the procatalyst of Example 1, triethylaluminum cocatalyst, and various SCA compositions, PEEB, DCPDMS/PEEB and DChDMS/PEEB. The resulting polymers are tested for Ti content (indicative of catalyst productivity) and XS. Plots of the results are contained in Figures 1 and 2. The results indicate that polymers having both low Ti content and low XS are capable of preparation utilizing the mixed SCA's of the invention.

Example 3

[0053] Bed settling tests were conducted using the fluidized bed reactor of Example 2 in order to approximate conditions of a power outage. In the tests, the compressor is stopped after the reactor reaches steady state propylene polymerization conditions thereby allowing the bed particles to settle onto the distributor plate. The maximum temperature indicated by the bed thermocouple is then recorded. For polypropylene, a maximum bed temperature less than 145 °C is desired to prevent sticking of polymer particles. For propylene/ethylene copolymers maximum bed temperatures should be lower, preferably not exceeding 106 °C. Results are contained in Table 2.

Table 2

Run	SCA (mol ratio)	Maximum Temp. (°C)
17	DCPDMS/PEEB (10/90)	106
18	MChDMS/PEEB (20/80)	98
19*	NPTMS/PEEB (25/75)	136
20*	PEEB	92
* Comparative, not an example of the invention		

Claims

1. A self-extinguishing catalyst composition for the polymerization of propylene or mixtures of propylene and one or more copolymerizable comonomers, said catalyst composition comprising one or more Ziegler-Natta procatalyst compositions comprising one or more transition metal compounds and one or more monoesters of aromatic carboxylic acid internal electron donors; one or more aluminum containing cocatalysts; and a premixture of two or more different selectivity control agents, said SCA premixture comprising (i) from 70 to 98 mol percent of ethyl p-ethoxybenzoate and (ii) from 30 to 2 mol percent of dicyclopentylmethoxysilane.
2. A catalyst composition of claim 1 wherein the internal electron donor is ethyl benzoate.
3. A catalyst composition according to any one of the preceding claims wherein the total quantity of selectivity control agent employed is limited to provide a molar ratio, based on transition metal, from 1 to 100.
4. A catalyst composition according to any one of the preceding Claims comprising from 75 to 95 mol percent ethyl p-ethoxybenzoate and from 25 to 5 mol percent of dicyclopentylmethoxysilane.
5. A catalyst composition according to Claim 4 comprising from 80 to 90 mol percent of ethyl p-ethoxybenzoate and from 20 to 10 mol percent of dicyclopentylmethoxysilane.
6. The catalyst composition according to Claim 4 comprising 95 mol percent of ethyl p-ethoxybenzoate and 5 mol percent of dicyclopentylmethoxysilane.
7. The catalyst composition according Claim 5 comprising 80 mol percent of ethyl p-ethoxybenzoate and 20 mol percent of dicyclopentylmethoxysilane.

8. The catalyst composition according to claim 1 wherein the Ziegler-Natta procatalyst composition is a morphology controlled procatalyst composition.

9. A method of polymerizing propylene or mixtures of propylene and one or more copolymerizable comonomers comprising:

mixing (i) the ethyl p-ethoxybenzoate and (ii) the dicyclopentylmethoxysilane to form the SCA premixture, prior to the contacting; and
contacting said monomer or monomer mixture at a temperature from 45 to 90 °C with a self-extinguishing catalyst composition comprising one or more Ziegler-Natta procatalyst compositions comprising one or more transition metal compounds and one or more internal electron donors selected from the group consisting of esters of aromatic monocarboxylic acids; one or more aluminum containing cocatalysts; and a premixture of two or more different selectivity control agents, said SCA premixture comprising (i) from 70 to 98 mol percent ethyl p-ethoxybenzoate and (ii) from 30 to 2 mol percent of dicyclopentylmethoxysilane.

10. A method according to Claim 9, comprising mixing from 75 to 95 mol percent ethyl p-ethoxybenzoate and from 25 to 5 mol percent of dicyclopentylmethoxysilane.

11. A method according to Claim 10, comprising mixing from 80 to 90 mol percent of ethyl p-ethoxybenzoate with from 20 to 10 mol percent of dicyclopentylmethoxysilane.

12. A method according to Claim 10, comprising mixing 95 mol percent of ethyl p-ethoxybenzoate with 5 mol percent of dicyclopentylmethoxysilane.

13. A method according to Claim 11, comprising mixing 80 mol percent of ethyl p-ethoxybenzoate with 20 mol percent of dicyclopentylmethoxysilane.

Patentansprüche

1. Selbsterlöschende Katalysatorzusammensetzung für polymerisation von Propylen oder Mischungen von Propylen und einem oder mehreren copolymerisierbaren Comonomer(en), wobei die Katalysatorzusammensetzung umfasst eine oder mehrere Ziegler-Natta-Prokatalysatorzusammensetzung(en), umfassend eine oder mehrere Übergangsmetall-Verbindung(en) und einen oder mehrere Monoester von aromatischen Carbonsäuren als innere Elektronendonoren;
einen oder mehrere Aluminium-enthaltende(n) Cokatalysator(en); und
eine Vormischung von zwei oder mehreren verschiedenen Selektivitätskontrollmitteln, wobei die SCA-Vormischung (i) von 70 bis 98 Molprozent Ethyl-p-ethoxybenzoat und (ii) von 30 bis 2 Molprozent Dicyclopentylmethoxysilan umfasst.

2. Katalysatorzusammensetzung nach Anspruch 1, wobei der innere Elektronendonator Ethylbenzoat ist.

3. Katalysatorzusammensetzung nach einem der vorhergehenden Ansprüche, wobei die Gesamtmenge an eingesetztem Selektivitätskontrollmittel begrenzt ist, um ein Molverhältnis auf der basis des Übergangsmetalls von 1 bis 100 bereitzustellen.

4. Katalysatorzusammensetzung nach einem der vorhergehenden Ansprüche, umfassend von 75 bis 95 Molprozent Ethyl-p-ethoxybenzoat und von 25 bis 5 Molprozent Dicyclopentylmethoxysilan.

5. Katalysatorzusammensetzung nach Anspruch 4, umfassend von 80 bis 90 Molprozent Ethyl-p-ethoxybenzoat und von 20 bis 10 Molprozent Dicyclopentylmethoxysilan.

6. Katalysatorzusammensetzung nach Anspruch 4, umfassend 95 Molprozent Ethyl-p-ethoxybenzoat und 5 Molprozent Dicyclopentylmethoxysilan.

7. Katalysatorzusammensetzung nach Anspruch 5, umfassend 80 Molprozent Ethyl-p-ethoxybenzoat und 20 Molprozent Dicyclopentylmethoxysilan.

8. Katalysatorzusammensetzung nach Anspruch 1, wobei die Ziegler-Natta-Prokatalysatorzusammensetzung eine Morphologie-kontrollierte Prokatalysatorzusammensetzung ist.

9. Verfahren zum Polymerisieren von Propylen oder Mischungen von Propylen und einem oder mehreren copolymerisierbaren Comonomer(en), umfassend:

das Mischen (i) des Ethyl-p-ethoxybenzoats und (ii) des Dicyclopentylmethoxysilan, um die SCA-Vormischung vor dem Inkontaktbringen zu bilden; und

das Inkontaktbringen des Monomers oder der Monomermischung bei einer Temperatur von 45 bis 90°C mit einer selbsterlöschenden Katalysatorzusammensetzung, umfassend eine oder mehrere Ziegler-Natta-Prokatalysatorzusammensetzung(en), umfassend eine oder mehrere Übergangsmetall-Verbindung(en) und einen oder mehrere innere(n) Elektronendonoren(en), ausgewählt aus der Gruppe bestehend aus Estern von aromatischen Monocarbonsäuren; einen oder mehreren Aluminium-enthaltende(n) Cokatalysator(en); und eine Vormischung aus zwei oder mehreren verschiedenen Selektivitätskontrollmitteln, wobei die SCA-Vormischung (i) von 70 bis 98 Molprozent Ethyl-p-ethoxybenzoat und (ii) von 30 bis 2 Molprozent Dicyclopentylmethoxysilan umfasst.

10. Verfahren nach Anspruch 9, umfassend das Mischen von 75 bis 95 Molprozent Ethyl-p-ethoxybenzoat und von 25 bis 5 Molprozent Dicyclopentylmethoxysilan.

11. Verfahren nach Anspruch 10, umfassend das Mischen von 80 bis 90 Molprozent Ethyl-p-11. Verfahren nach Anspruch 10, umfassend das Mischen von 80 bis 90 Molprozent Ethyl-p-ethoxybenzoat mit von 20 bis 10 Molprozent Dicyclopentylmethoxysilan.

12. Verfahren nach Anspruch 10, umfassend das Mischen von 95 Molprozent Ethyl-p-ethoxybenzoat mit 5 Molprozent Dicyclopentylmethoxysilan.

13. Verfahren nach Anspruch 11, umfassend das Mischen von 80 Molprozent Ethyl-p-ethoxybenzoat mit 20 Molprozent Dicyclopentylmethoxysilan.

Revendications

1. Composition de catalyseur auto-extinguible servant à faire polymériser du propylène ou des mélanges de propylène et d'un ou de plusieurs comonomère(s) copolymérisable(s), laquelle composition de catalyseur comprend :

- une ou plusieurs composition(s) de pro-catalyseur de Ziegler-Natta, comprenant un ou plusieurs composé(s) de métal de transition et un ou plusieurs monoester(s) d'acide carboxylique aromatique en tant que donneur (s) interne(s) d'électrons ;
- un ou plusieurs co-catalyseur(s) contenant de l'aluminium ;
- et un pré-mélange de deux agents de régulation de la sélectivité (ARS) différents ou plus, lequel pré-mélange d'ARS comprend

- i) de 70 à 98 % en moles de para-éthoxy-benzoate d'éthyle,
- ii) et de 30 à 2 % en moles de dicyclopentyl-diméthoxy-silane.

2. Composition de catalyseur conforme à la revendication 1, dans laquelle le donneur interne d'électrons est du benzoate d'éthyle.

3. Composition de catalyseur conforme à l'une des revendications précédentes, dans laquelle la quantité totale d'agents de régulation de la sélectivité employée est limitée de manière que, par rapport au métal de transition, le rapport molaire vaille de 1 à 100.

4. Composition de catalyseur conforme à l'une des revendications précédentes, comprenant de 75 à 95 % en moles de para-éthoxy-benzoate d'éthyle et de 25 à 5 % en moles de dicyclopentyl-diméthoxy-silane.

5. Composition de catalyseur conforme à la revendication 4, comprenant de 80 à 90 % en moles de para-éthoxy-benzoate d'éthyle et de 20 à 10 % en moles de dicyclopentyl-diméthoxy-silane.

6. Composition de catalyseur conforme à la revendication 4, comprenant 95 % en moles de para-éthoxy-benzoate d'éthyle et 5 % en moles de dicyclopentyl-diméthoxy-silane.

7. Composition de catalyseur conforme à la revendication 5, comprenant 80 % en moles de para-éthoxy-benzoate d'éthyle et 20 % en moles de dicyclopentyl-diméthoxy-silane.

8. Composition de catalyseur conforme à la revendication 1, dans laquelle la composition de pro-catalyseur de Ziegler-Natta est une composition de pro-catalyseur à morphologie maîtrisée.

9. Procédé de polymérisation de propylène ou de mélanges de propylène et d'un ou de plusieurs comonomère(s) copolymérisable(s), lequel procédé comporte les étapes suivantes :

- mélanger

- i) du para-éthoxy-benzoate d'éthyle,
- ii) et du dicyclopentyl-diméthoxy-silane,

pour former le pré-mélange d'ARS, avant la mise en contact,

- et mettre ledit monomère ou mélange de monomères en contact, à une température de 45 à 90 °C, avec une composition de catalyseur auto-extinguible comprenant :

- une ou plusieurs composition(s) de pro-catalyseur de Ziegler-Natta, comprenant un ou plusieurs composé(s) de métal de transition et un ou plusieurs donneur(s) interne(s) d'électrons choisi(s) dans l'ensemble constitué par les esters des acides monocarboxyliques aromatiques ;

- un ou plusieurs co-catalyseur(s) contenant de l'aluminium ;

- et un pré-mélange de deux agents de régulation de la sélectivité (ARS) différents ou plus, lequel pré-mélange d'ARS comprend

- i) de 70 à 98 % en moles de para-éthoxy-benzoate d'éthyle,
- ii) et de 30 à 2 % en moles de dicyclopentyl-diméthoxy-silane.

10. Procédé conforme à la revendication 9, qui comporte le fait de mélanger de 75 à 95 % en moles de para-éthoxy-benzoate d'éthyle et de 25 à 5 % en moles de dicyclopentyl-diméthoxy-silane.

11. Procédé conforme à la revendication 10, qui comporte le fait de mélanger de 80 à 90 % en moles de para-éthoxy-benzoate d'éthyle et de 20 à 10 % en moles de dicyclopentyl-diméthoxy-silane.

12. Procédé conforme à la revendication 10, qui comporte le fait de mélanger 95 % en moles de para-éthoxy-benzoate d'éthyle et 5 % en moles de dicyclopentyl-diméthoxy-silane.

13. Procédé conforme à la revendication 11, qui comporte le fait de mélanger 80 % en moles de para-éthoxy-benzoate d'éthyle et 20 % en moles de dicyclopentyl-diméthoxy-silane.

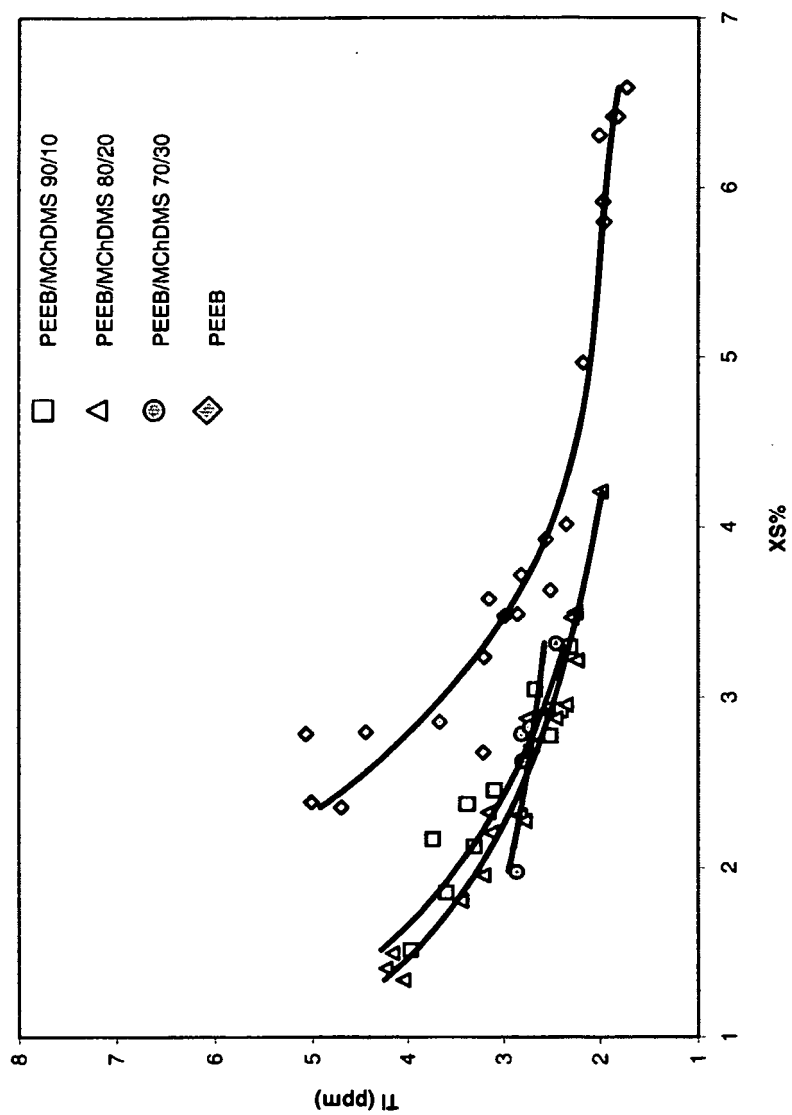


Fig. 1

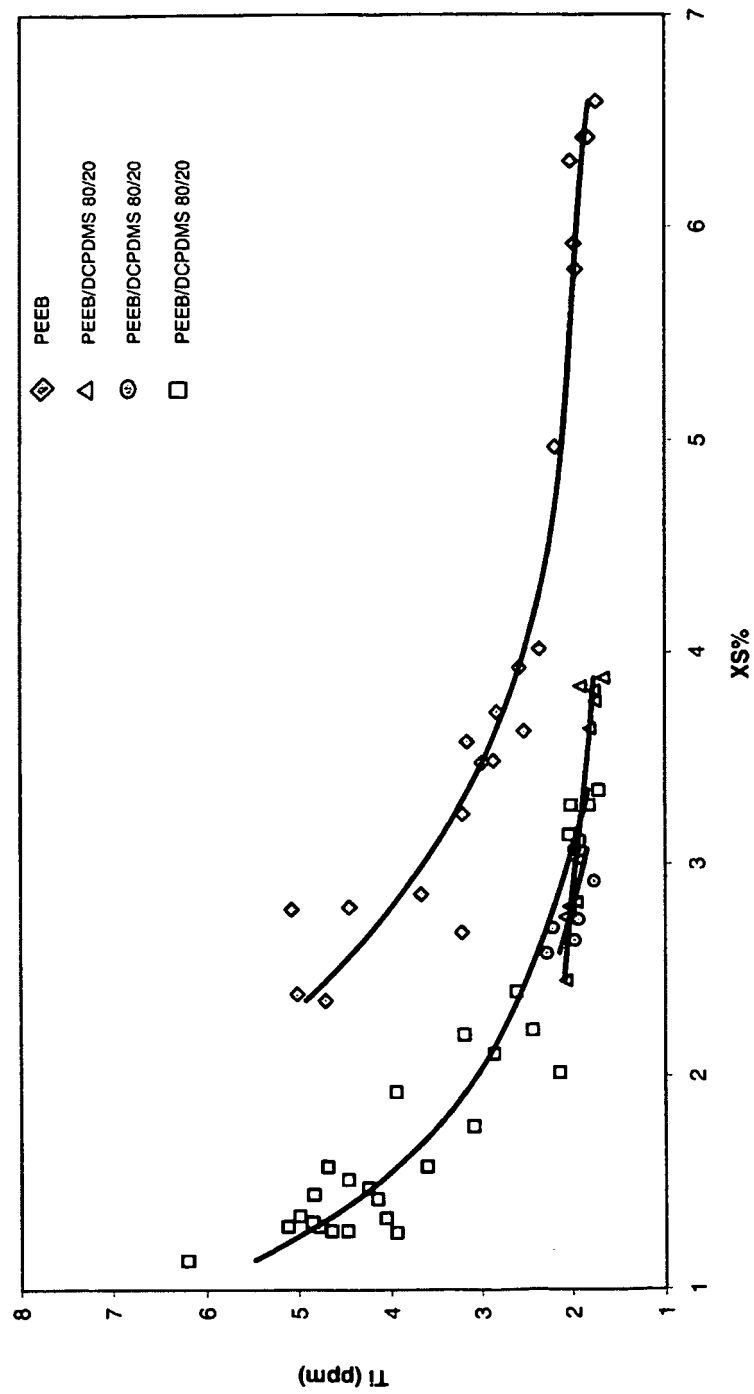


Fig. 2

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